Different fields contributed to the expansion of S&E degrees at different time periods, and several fields show a declining number of degrees in the 1990s. The number of degrees in the physical and mathematical sciences peaked in the early 1970s, slowly declined in the 1980s, and then leveled off in the 1990s. In contrast, engineering and computer science degrees peaked in the mid-1980s, quickly declined, and leveled off in the 1990s. Trends in the biological sciences showed a long, slow decline in earned degrees in the 1980s but a reversal of this trend in the 1990s. The only fields with an increasing number of earned degrees in the 1990s are psychology and the biological sciences.

Curriculum Reform in Undergraduate Education

The Steelman report's concern for improving the quality of undergraduate education has been of recurring national interest and has gained momentum in the past 10 years. Individual faculty, departments, professional societies, and institutions of higher education are increasingly involved in reform to enhance undergraduate teaching and the curriculum in mathematics, the various fields of sciences, engineering, and technology. Since 1992, faculties from 700 institutions of higher education have participated in one or more workshops to strengthen student interest and success in mathematics and science (Project Kaleidoscope 1999). Reforms include, for example, infusing more investigative learning into the curricula, using innovative computer laboratories and learning technologies, increasing undergraduate research experiences, and encouraging interdisciplinary collaboration in team teaching.

Reforms are directed at both science and nonscience majors. Improved introductory and advanced courses that attract and retain science majors seek both to augment the S&E workforce needed in the U.S. economy and to prepare adequate numbers of students for advanced study. Designing successful introductory courses is also aimed at strengthening the understanding of the processes and methods of science for all college students. This broader attention to curricular reform in mathematics and science courses for all students is essential for improving future K–12 teachers, public understanding of scientific issues, and citizen participation in an increasingly technological society. (See sidebar, "Institution-Wide Reform.")

Institution-Wide Reform

Since curricular changes and facility improvements occur slowly without departmental and institutional backing, a major theme of undergraduate education reform in S&E courses is the so-called institution-wide reform. The aim of institution-wide reform is to revitalize undergraduate education on a more comprehensive, self-sustaining, and interdisciplinary basis. Recently initiated assessments of these initiatives will attempt to develop quantitative indicators on faculty, students, and institutions (Ruskus 1999). For example, faculty assessment will include the proportion of S&E faculty revising their curricula for best practices in teaching, collaborating with other faculty in developing courses, and publishing research on improved teaching and learning. Student outcomes will include the proportion of students completing S&E courses that reflect best practices, enrollment in follow-on courses, completion rates for S&E majors, and an undergraduate research experience or internship.

International Comparison of First University Degrees in S&E

Diffusion of Higher Education in S&E Fields

The worldwide expansion in advanced S&E education capabilities is particularly evident in Europe, Asia, and the Americas.[9] One indicator of this diffusion of S&E education capacity is the rapidly increasing number of students completing university degrees in S&E. (See appendix table 4-18 and NSB 1998.) Another indicator is the expansion of doctoral programs in S&E and graduate education reforms to improve the quality of research and build national innovation capacity. (See "International Comparison of Doctoral Degrees in S&E.[10])

In 1997, more than 2.7 million students worldwide earned a first university degree[11] in science or engineering. (Note that the worldwide total includes only countries for which recent data are available, primarily in the Asian, European, and American regions, and is therefore an underestimation.) These 2.7 million degrees are evenly balanced among the broad S&E fields: about 900,000 students earned degrees in each of the broad fields of natural sciences,[12] social sciences, and engineering. (See appendix table 4-18.)

From among reporting countries, more than 1 million of the 2.7 million S&E degrees were earned by Asian students within Asian universities. Students across Europe (including Eastern Europe and Russia) earned more than three-quarters of a million first university degrees in S&E. And students in the North American region earned one-half million bachelor-level degrees. These three regions, Asia, Europe, and North

[9]Data in this section are primarily taken from the National Science Foundation, Science Resources Studies Division, *Global Database on Human Resources for Science*, and are based on national and international sources. (See appendix table 4-18.)

[10]For other indicators of the development of science and technology infrastructure in several world regions, see other chapters in this volume on research and development (chapter 2), bibliometrics (chapter 6), and patents and high-technology trade (chapter 7).

[11]A first university degree refers to completion of an undergraduate degree program. These degrees are classified as level 6 in the International Standard Classification of Education, although individual countries use different names for the first terminal degree: for example, *laureata* in Italy, *diplome* in Germany, *maitrise* in France, and bachelor's degree in the United States and in Asian countries.

[12]The natural sciences comprise the physical, earth, atmospheric, oceanographic, biological, and agricultural sciences; mathematics; and computer sciences.

America, account for the large majority (88 percent) of reported S&E bachelor's degrees earned worldwide. Students in Asia and Europe earn more first university degrees in engineering than in natural sciences and generally more in natural sciences than in social sciences, whereas in North America earned degrees show the reverse. (See figure 4-12 and appendix table 4-18.)

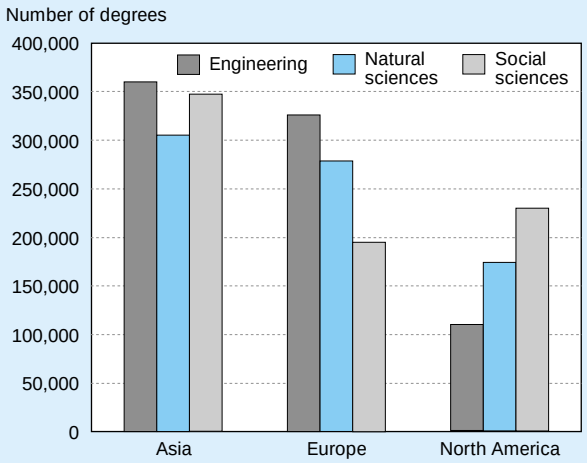
Growth Rates in S&E Fields

The higher growth rate in NS&E degrees in Asia and Europe than in North America has been reported earlier (NSB 1998; NSF 1993; NSF 1996a). For example, in the past decade, the average annual growth rate in earned NS&E degrees in the Asian and European regions was more than 4 percent. In contrast, in the North American region the number of NS&E degrees declined at an average annual rate of 0.9 percent during this same time period.

Trends in Asia

Recent changes in higher education in these regions, however, are less well known. These changes include a leveling off of bachelor-level S&E degrees and a shift in emphasis to doctoral S&E training. (See figures 4-13 and 4-14.) Bachelor-level engineering degrees peaked in Asia in 1995 at 324,500 and declined slightly in 1996. Similarly, natural science degrees peaked at 191,500 in 1995 and dropped slightly in 1996. (See "International Comparison of Doctoral Degrees in S&E" and sidebar, "Graduate Reforms in Europe, Asia, and Latin America.") Bachelor's degrees will again begin to increase around 2003–04, from the large expansion of undergraduate enrollment in China in 1999 (Plafker 1999).

Figure 4-12.
First university degrees in S&E in selected countries, by region: 1997 or most recent year



NOTES: Natural sciences include physical, biological, agricultural, earth, atmospheric, and oceanographic sciences, mathematics, and computer sciences. Social sciences include psychology, sociology and other social sciences.

See appendix table 4-18 for countries included within each region.

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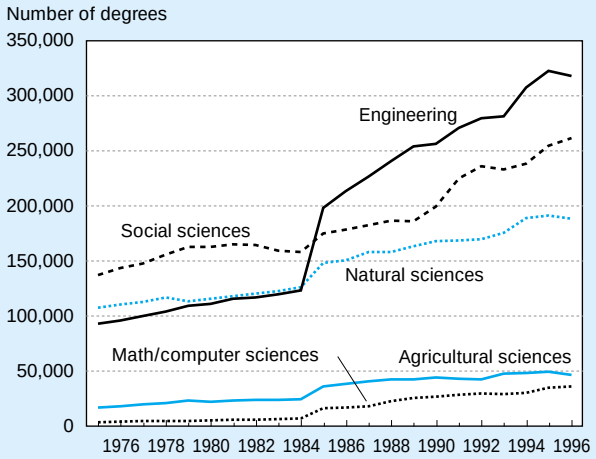
Figure 4-13.
Bachelor's degrees in S&E fields earned within selected Asian countries: 1975–96



NOTES: The steep rise in degrees in 1985 reflects the inclusion of Chinese data from that year on. Natural sciences include physical, biological, earth, atmospheric, and oceanographic sciences. Social sciences include psychology, sociology, and other social sciences.

See appendix table 4-19 for Asian countries included.

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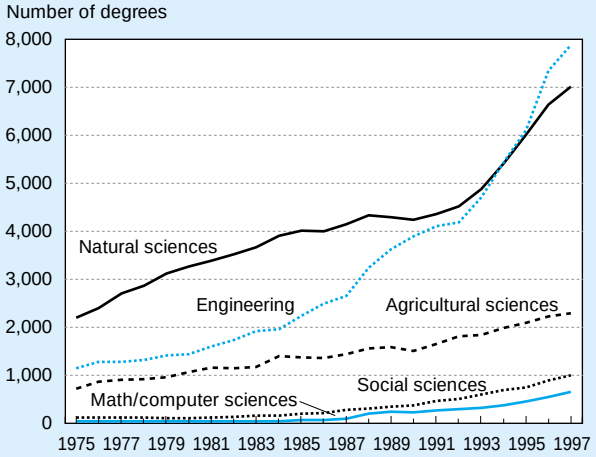
Figure 4-14.
Doctoral degrees in S&E fields earned within selected Asian countries: 1975–97



NOTES: Natural sciences include physical, biological, earth, atmospheric, and oceanographic sciences. Social sciences include psychology, sociology, and other social sciences.

See appendix table 4-19 for Asian countries included.

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In addition, Asian countries are reexamining the field mix of sciences within their universities, to balance the previous concentration on physical science and engineering and meet new needs. For example, Japan would like to increase study in the biological sciences and biotechnology for the health research needs of an aging population and for bioengineering industries of the future (see Government of Japan 1998a, 1998b, 1999). Text table 4-5 shows the number of biology and engineering degrees in Japan, their percent of total degrees, and comparative data from the United States. Within Japan, bachelor's degrees earned in the biological sciences are less than 1 percent of total degrees, while engineering degrees represent more than 19 percent of degrees earned at this level. Similarly, large differences exist at the master's and doctoral level. In contrast, in the United States, biology and engineering degrees represent a similar proportion of total degrees at both the bachelor's and doctoral levels. At the bachelor's level, biology and engineering each represent about 5 percent of total U.S. degrees; at the doctoral level, 14 to 15 percent of total degrees.

Trends in Europe

Recent European developments include a continually broadening access to higher education, more mobility for students and faculty among the countries of the European Union, and graduate education reform. European countries are introducing and expanding their short-cycle, three- to four-year undergraduate programs, alongside their traditional universities that require six to seven years for completion of the first university degree (equivalent to a master's). For example, Germany has increased the shorter cycle, four-year undergraduate institutions, called *Fachhochschulen*, and revised first university degree programs to shift more of the research training to the doctoral level (NSF 2000).

Comparison of Proportion of Degrees in S&E and non-S&E Fields Across Countries

How does the U.S. educational system compare with other countries in its emphasis on S&E in undergraduate programs? One indicator of focus on science and engineering is the proportion of degrees earned in S&E and non-S&E fields. Considering total degrees across all regions, the 2.7 million S&E degrees represent 42 percent of all first university degrees. (See appendix table 4-20.) However, some countries emphasize S&E fields in higher education more than others do. In several large countries—Japan, Russia, and Brazil—students earn more than 60 percent of their first university degrees in S&E fields, and in China, 72 percent do. In contrast, in the United States, students earn their degrees in a wide range of S&E and non-S&E fields: U.S. students earn about one-third of their bachelor-level degrees in S&E fields, mainly in the social sciences. (See appendix table 4-20.)

Of the first university degrees across all regions, approximately 14 percent are earned in each of the broad fields of natural sciences, social sciences, and engineering. There are strong differences in field emphases across countries, however. Engineering represents 46 percent of the earned

Text table 4-5.
Earned degrees in biology and engineering in U.S. and Japanese universities, by level: 1996

Country and field	Bachelor's			Master's			Doctoral		
	Total	Men	Women	Total	Men	Women	Total	Men	Women
				Number					
United States									
Total, all degrees	1,179,815	528,000	651,815	408,932	180,360	228,572	42,415	25,470	16,945
Engineering	63,114	51,798	11,316	27,763	23,009	4,752	6,305	5,529	776
Biology	62,081	29,216	32,865	6,286	2,945	3,341	5,723	3,308	2,415
Japan									
Total, all degrees	512,814	341,116	171,698	47,747	38,022	9,725	8,968	7,477	1,491
Engineering	99,428	92,097	7,331	22,622	21,454	1,168	2,127	2,016	111
Biology	1,875	1,139	736	794	572	222	192	159	33
				Percent					
United States									
Total, all degrees	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Engineering	5.3	9.8	1.7	6.8	12.8	2.1	14.9	21.7	4.6
Biology	5.3	5.5	5.0	1.5	1.6	1.5	13.5	13.0	14.3
Japan									
Total, all degrees	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Engineering	19.4	27.0	4.3	47.4	56.4	12.0	23.7	27.0	7.4
Biology	0.4	0.3	0.4	1.7	1.5	2.3	2.1	2.1	2.2

SOURCES: National Science Foundation, Science Resources Studies Division, *Science and Engineering Degrees 1966–96*, NSF 99-330, Author, Susan T. Hill (Arlington, VA: 1999); Government of Japan, Ministry of Education, Science, and Culture (Monbusho), *The Monbusho Survey of Education* (Tokyo: annual series, 1996).

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bachelor's degrees in China, about 30 percent in Sweden and Russia, and about 20 percent in Japan and South Korea. In contrast, students in the United States earn only 5 percent of bachelor-level degrees in engineering fields. Countries with high concentration of university degrees in the natural sciences include Ireland (34 percent), France and India (20 percent), and the United Kingdom (18 percent). (See appendix table 4-20.)

Participation Rates in University Degrees and S&E Degrees

The concern raised by the Steelman report regarding the need to prepare a sufficient number of students for advanced graduate education and research in science not only has remained of national interest but has broadened. The issue has been broadened from ensuring adequate numbers of students willing and able to enter graduate S&E programs to preparing all citizens for life and employment in a high-technology economy. A high ratio of the college-age population earning university degrees correlates with better public understanding of science, and a high proportion of the college-age population earning an NS&E degree is an indicator of the technical skill level of those entering the workforce.

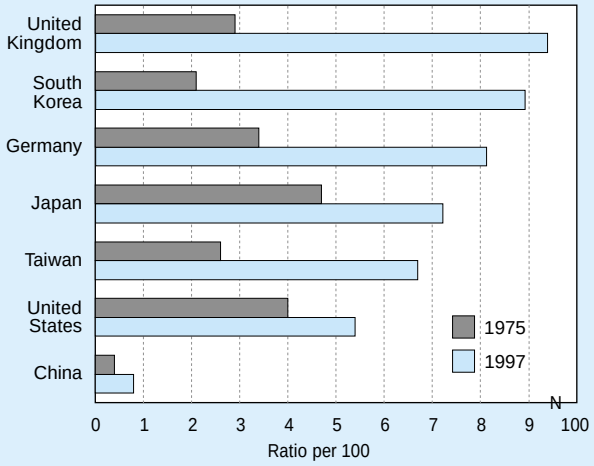
The ratio of U.S. bachelor's degrees to the college-age cohort is relatively high: 32 per hundred. Only a handful of countries (the United Kingdom, Canada, Australia, and New Zealand) have higher ratios. However, the ratio of NS&E degrees to the college-age population in more than a dozen Asian and European countries is higher than in the United States. South Korea and Taiwan dramatically increased their ratio of NS&E degrees to their 24-year-olds, from 2 per hundred in 1975 to 7 per hundred in 1997 in Taiwan and 9 per hundred in South Korea. Japan has maintained a high ratio of NS&E degrees to its 24-year-old population since the 1970s, with a slight decline in the late 1980s. The higher ratios after 1995 reflect an increasing number of NS&E degrees and the declining college-age population in Japan. Their college-age cohort will continue to decline until 2010. (See appendix table 4-18 for 1997 data and NSF 1993 for trend data on Asian countries, and appendix table 4-7 for the trends on declining college-age cohorts of major industrialized countries.)

Asia's two giants, India and China, have low participation rates in NS&E degrees. India, with its huge, growing population, is maintaining its participation rate of 1 per hundred. China, with an even larger population, has doubled its participation rate in the past decade, from 0.4 per hundred in 1985 to 0.9 per hundred in 1996. (See NSF 1993 for trend data, figure 4-15 and appendix table 4-18.)

A declining pool of college-age students in Europe has not resulted in declining numbers of NS&E degrees as in the United States. The size of the college-age cohort in Europe has declined 21 percent, from 29.7 million in 1985 to 23.5 million in the year 2000.[13] (See appendix table 4-7.) Among European countries, participation rates in NS&E degrees have grown to more than offset the declining population, most notably in Germany and the United Kingdom. For example, the ratio of NS&E degrees to the German college-age cohort has increased from 3 per hundred to more than 8 per hundred in the past 20 years. Similarly, in the United Kingdom, the ratio increased from 3 to more than 9 per hundred in this same time period. (See NSF 1996a and appendix table 4-18.)

In contrast, overall participation rates have remained relatively constant in the United States; the ratio of NS&E degrees to the college-age population has remained between 4 and 5 per hundred for the past three decades. That is, students do not show less interest or achievement in earning natural science or engineering degrees; neither do they show more. Demographics have changed significantly, however. As discussed in "Demographics and U.S. Higher Education," the U.S. college-age population decreased by 21 percent from 1980 to 2000. (After this 20-year decline, the U.S. college-age cohort will begin to increase in 2001.) The effect of this demographic trend is partially offset by increasing participation rates for women and underrepresented minorities. Although the decreasing size of the college-age cohort resulted in a downturn in the number of degrees in several NS&E fields, fields in which women are very highly represented (biological sciences and psychology) have produced increasing numbers of degrees in the 1990s. (See appendix table 4-17.)

Figure 4-15.
Ratio of NS&E degrees to the 24-year-old population, by country



NOTES: The ratio is the number of natural science and engineering degrees to the 24-year-old population, on a scale of 1 to 100. China's data are for 1985 and 1996. Other countries' data are for 1975 and 1997.

SOURCES: National Science Foundation, Science Resources Studies Division (NSF/SRS), *Human Resources for Science and Technology: The Asian Region,* NSF 93-303 (Washington, DC: 1993); NSF/SRS, *Human Resources for Science and Technology: The European Region,* NSF 96-319 (Arlington, VA: 1996); and appendix table 4-18.

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[13]The European college-age cohort will begin to increase again in 2005.